Air Vehicles Directorate
Air Force Research Laboratory

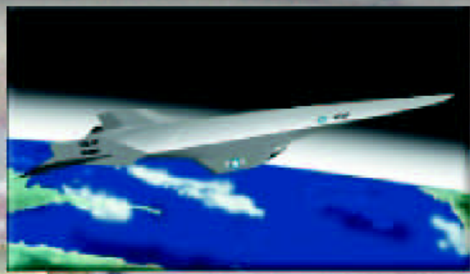
MDT

MULTIDISCIPLINARY TECHNOLOGIES

CENTER

Revolutionary Capability Through Multidisciplinary Design

Multidisciplinary Technologies (MDT) Research for Air Vehicles



The Air Force Research Laboratory (AFRL), headquartered at Wright-Patterson Air Force Base, is one of the largest complexes in the world dedicated to scientific and engineering excellence in flight-sciences. The Laboratory's Air Vehicles Directorate (VA) is responsible for leading the development and implementation of many aerospace technologies, such as aerodynamics, structures, and flight controls, and system concepts such as unmanned air vehicles, access to space, and sustainment. Design methods developed from a multidisciplinary perspective are required to successfully exploit these technologies and enable revolutionary air vehicle designs and system level capabilities.

In support of the AFRL goals, the mission of the MDT Center is to identify, develop, and improve critical, military specific air vehicle technology design tools, methods and processes to support innovative and affordable military aerospace vehicle development. This capability enables the Center to serve the Air Force by quickly identifying innovative, viable aerospace vehicle concepts. To achieve this mission, core competencies are maintained in design and integration, optimization methods, aerospace sciences, and computational analysis. This mission is based in basic and exploratory research and supports development projects leading to new system concepts in AFRL and the Air Force.

Current Research Areas for Multidisciplinary Design and Analysis

Design Processes & Air Vehicle Design

Develop design processes and a framework for technology assessment, application and invention. Use these processes to develop air vehicle technologies that exploit and maximize the benefits of previously unused technology interactions. The payoff is the ability to quantify benefits of new technologies in a system context and identify future technology developments for an optimal system design.

Innovative Air Vehicle Technologies

Identify and evaluate leading edge air vehicle technologies, such as micro adaptive flow control, that will lead to new and unique system capabilities and provide methodologies suitable for preliminary design of air vehicles that utilized these technologies. Payoffs are the ability to rapidly identify, assess and exploit leading edge technology concepts.

Computational Aeroelasticity

Understand physical processes associated with aeroelastic behavior of flight vehicles and develop highly efficient computational tools that accurately model them. Payoffs are substantial reductions in design time due to rapid analysis capability and reductions in redesigns due to a more complete understanding and modeling of the physics.

Modeling of Nonlinear Systems

Conduct basic research to understand multi-physics interactions and the impact of uncertainties on the behavior of nonlinear systems. Develop design-based methods involving high-fidelity techniques for analyzing nonlinear systems. Payoffs include improved designs of new vehicle concepts for the war fighter through nonlinear optimization.

Impact on the Air Force

NEAR TERM

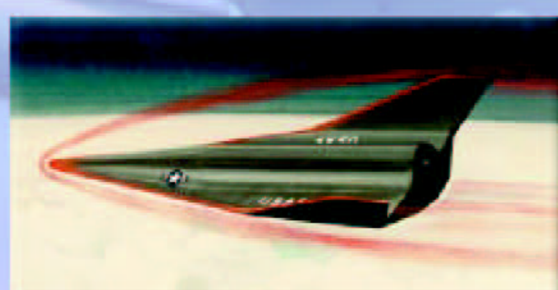
Store Certification & Active Aerolastic Wing (AAW)

High-fidelity (HF) analysis of aerodynamic-structural interactions of current systems, such as the F-16, is contributing to reducing flight hours required for store certification. HF analyses of the AAW concept supports the Air Vehicle Directorate's AAW Program with flow characteristics and structural requirements that are critical to developing AAW design guidance for future USAF air vehicles.

MID TERM

VA Integrating Concept Programs

Center design teams are supporting the VA Integrating Concept Programs by assessing the capabilities of and identifying technology requirements for new air vehicle concepts, such as the sensorcraft (left). These are multidisciplinary design teams that not only consider classic design issues such as aerodynamic and structural performance but also new metrics such as antenna performance.

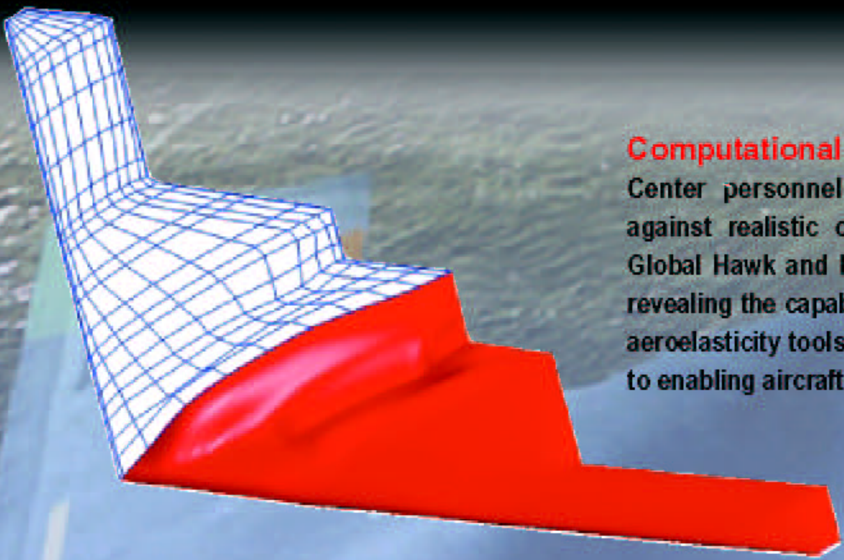


FAR TERM

Revolutionary Air Vehicle Concepts

Air vehicles (such as advanced unmanned combat air vehicles (left) and hypersonic flight vehicles (above)) for the Air Force of the 21st Century will take advantage of advanced technologies, such as flow control and multifunctional structures. Vehicle concepts that maximize performance of these technologies will be enabled by multidisciplinary methodologies and energy based design processes developed in the Center.

MDT In Action-Technology Development

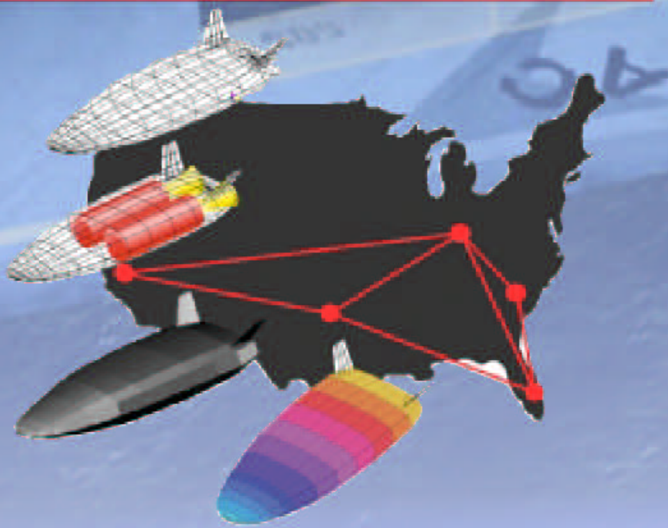


Computational Aeroelasticity (CAE)

Center personnel are validating CAE programs against realistic configurations such as the B-2, Global Hawk and high speed vehicle concepts and revealing the capabilities of a suite of computational aeroelasticity tools. Tools like these are the prelude to enabling aircraft certification by analysis.

Web Based Design Process

The Center is developing enhancements of the Adaptive Modeling Language to allow multiple users to collaborate concurrently on a single design model. These users can be at distributed sites and connected through the internet. This capability will enable large reductions in vehicle design time.



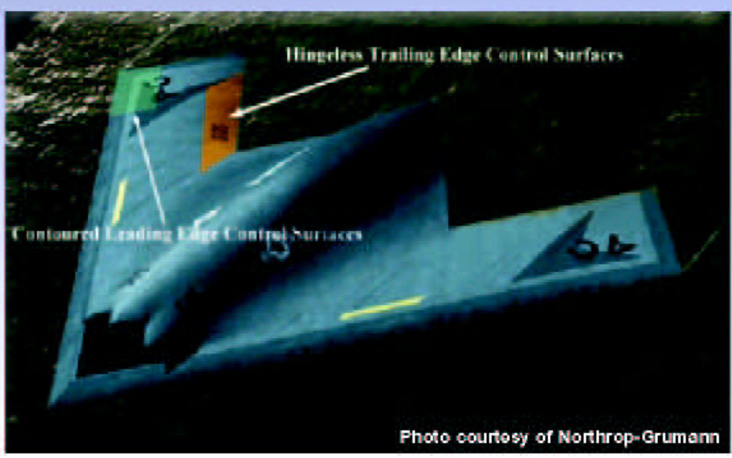


Photo courtesy of Northrop-Grumann

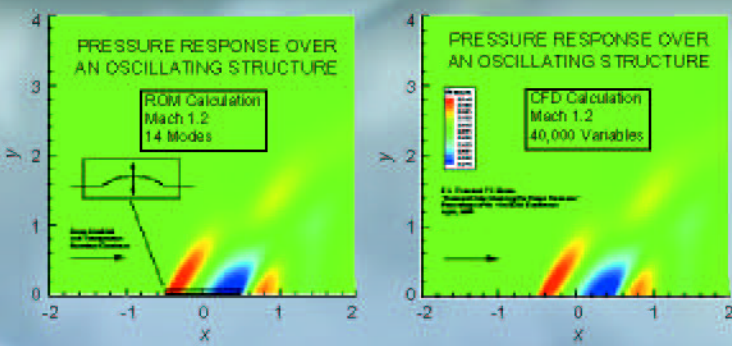
Adaptive Structures

The Center is managing a DARPA sponsored program to design, test, and validate adaptive structure concepts for combat UAVs. Northrop-Grumann is the prime contractor. Technical participation by Center personnel and NASA Langley also play a major role toward understanding USAF applications of this technology. Low bandwidth concepts to improve takeoff and landing performance have been successfully demonstrated.

MDT in Action - Basic Research

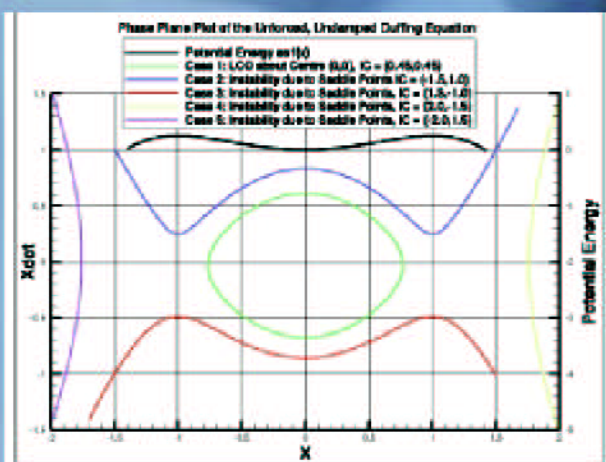
Computational Aeroelasticity

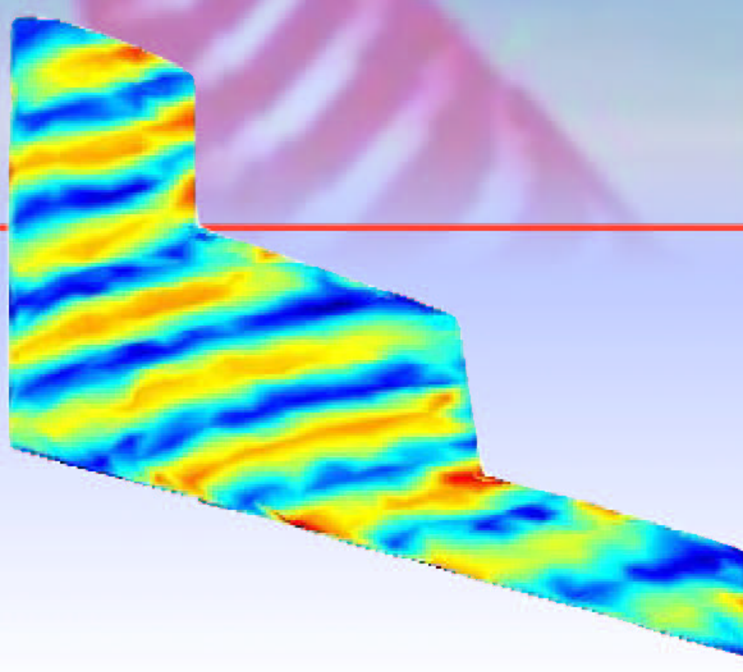
Complex, nonlinear physics can be accurately modeled while reducing the dimensionality of high-fidelity simulations. As exemplified in the figures at the right time-integration of the Euler equations can be accurately carried out with 14 modes instead of 40,000 discrete variables. Reduced order modeling techniques like this will enable up to 100 times faster analysis of critical design conditions metrics.



System Nonlinearities

Typically depicted by the phase plane plot of the Duffing system (left), nonlinear mathematical systems, such as the Navier-Stokes equations, possess a sensitivity to initial conditions due to the multi-valued nature of their solution. Proper investigation of these sensitivities and establishing the stability bounds of nonlinear systems are essential to prime them for optimization. It is also critical to accomplish this as quickly as possible via faster algorithms, multiprocessing and reduced order methods to enable new design processes such as analytical certification of aircraft.





Design for Radar Cross Section

Radar Cross Section's dependence on exterior shape makes it a strong factor in preliminary design of air vehicles. Several tools are available for this purpose. One of which is the the method of moments. This analytical tool determines the amplitude of surface currents in the frequency domain. Regions with strong amplitudes become candidates for reshaping or the application of radar absorbing materials. The Center is exploring several of these techniques and understanding how to most efficiently bring them into the design environment.

Multidisciplinary Research for Aerospace Systems

System Integration & Cost

Emerging Technologies

Computational Sciences

Aerospace Sciences

Design Methods & Processes

Mission Requirements

Our Commitment

We will market our products, services and capabilities to serve the interests of the US Air Force. We will continuously strive to understand the evolving needs of the US Air Force to ensure dominant technology for our warfighters.

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